

## Could native *Araucaria* forests be managed for timber production on small farms in southern Brazil?

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### ARTICLE INFO

#### Keywords:

Harvest scenarios  
*Araucaria angustifolia*  
Cutting cycles  
Growth model

### ABSTRACT

Most native *Araucaria* forests exist on small farms in the southern region of Brazil, with only a small area (< 1%) of coverage still present in the protected areas of mature forests. Current law restricts forest management for timber production in native *Araucaria* forests by prohibiting harvesting the main tree species—*Araucaria angustifolia* and other important commercial timber species. As a consequence, the forested areas of some small farms have been illegally converted to other land uses, resulting in the area of native *Araucaria* forest coverage in southern Brazil having been significantly reduced in recent decades. To gain a better understanding of the consequences of managing native *Araucaria* forests on small farms for timber production, we used a growth model to simulate nine different harvesting scenarios using different harvest intensities and cutting cycles to simulate *A. angustifolia*'s long-term recovery after harvesting. The harvesting scenarios considered sustainable for supplying *A. angustifolia* timber were further tested in simulations of overall timber forest management that included harvesting angiosperm tree species in addition to *A. angustifolia*. The simulations were performed with data collected from 48 plots established on 19 small farms located in southern Brazil. Of the nine harvesting scenarios tested, four were considered sustainable for producing *A. angustifolia* timber: (1) removing 10% of the *A. angustifolia* basal area ( $G_{\text{arauc}}$  in  $\text{m}^2 \text{ha}^{-1}$ ) in 5-yr cutting cycles; (2) removing 20% of the  $G_{\text{arauc}}$  in 10-yr cutting cycles; (3) removing 35% of the  $G_{\text{arauc}}$  in 20-yr cutting cycles; and (4) removing 40% of the  $G_{\text{arauc}}$  in 25-yr cutting cycles. These four sustainable *A. angustifolia* harvesting scenarios remained sustainable when managing the forest as a whole by including some angiosperm tree species harvesting as well. This indicates that managing forests for timber production may be a promising pursuit to develop on the small farms of southern Brazil.

### 1. Introduction

Native *Araucaria* forests occur mainly in southern Brazil and are a part of the Atlantic Forest biome. Besides Brazil, this forest type also occurs in the northeastern region of Argentina and is scattered in eastern Paraguay (Souza, 2007). Native *Araucaria* forests comprise hundreds of tree species, but the main one is *Araucaria angustifolia*, belonging to the Araucariaceae family. It is considered the most important conifer in Brazil due to its commercial importance for good quality timber and the production of edible seeds that are prized for human consumption, especially in southern Brazil.

In the early eighteenth century, native *Araucaria* forests dominated the landscape in southern Brazil (Souza et al., 2008). The colder climate relative to other regions of the country and the presence of fertile soils attracted many immigrant families (mainly from Europe) to southern

Brazil, where they settled on small farms between the eighteenth and nineteenth centuries and developed agricultural communities (Waibel, 1950). While agricultural productivity abruptly increased with the arrival of new farming techniques, the southern region's native forest coverage lost area due to forest conversion. There was also intense exploitation of the native forests at that time because there were no restrictions on forest use. Until the mid-1980s, Brazilian law placed few restrictions on the timber production management of native *Araucaria* forests, with the harvest of virtually any tree with a diameter larger than 40-cm at breast height being permitted (Basso, 2010). As a consequence, the native *Araucaria* forests in southern Brazil have been drastically reduced from their natural coverage.

Today, most native *Araucaria* forests are fragmented, representing just 3% of the original total coverage, and occur mainly on small farms (Bittencourt and Sebbenn, 2009; Silva and Schmitt, 2015). Few areas

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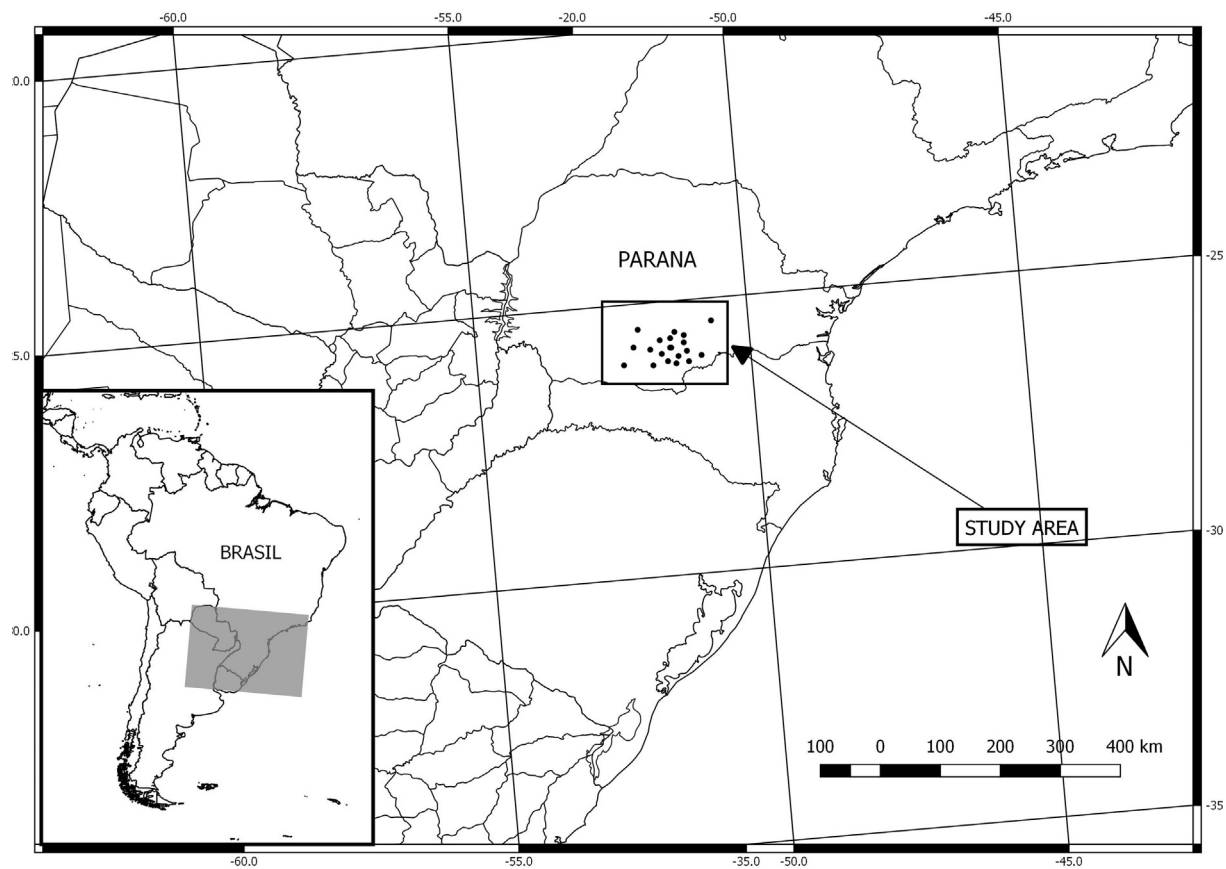


Fig. 1. Map of the study area illustrating the 19 small farms where the data were collected.

within the protected regions are still covered by mature forests. Despite current law prohibiting the harvesting of naturally occurring *A. angustifolia* and other important tree species in native *Araucaria* forests such as *Ocotea porosa*, *Cedrela fissilis*, and *Ocotea odorifera*, harvesting these species is still permitted for timber and non-timber production on established tree plantations. The prohibition on harvesting *A. angustifolia* is because the species is classified as critically endangered (Bittencourt, 2007; Silveira et al., 2006; Souza, 2007). However, the inclusion of *A. angustifolia* as an endangered species is highly questionable. Several studies conducted in different parts of southern Brazil have ranked *A. angustifolia* as one of the top 3 most important tree species among dozens of others, reporting a value index (IVI) of highest importance (Galvão et al., 1989; Negrelle and Leuchtenberger, 2001; Rondon Neto et al., 2002; Sanquetta et al., 2007; Silva and Marconi, 1990; Valério et al., 2008), which is computed based on the relative frequency, dominance, and abundance of all tree species in a specific study area. This contradicts the notion that *A. angustifolia* is critically endangered.

Small farms retain only the minimum area of native vegetation required by law, which in southern Brazil must account for 20% of the total area of a rural property. Because they do not receive any financial return from the forested areas on their farms, the landowners often think of them as unproductive (Sanquetta and Mattei, 2006). The lack of political incentives for active forest management of the native *Araucaria* forests has led to some small landowners not retaining the 20% of forested area required by law and illegally opting for other land uses, primarily agricultural, but also pastureland and plantations of commercial exotic timber species (Orellana et al., 2016). Not only has the area of forest coverage been reduced, but so too has biodiversity been lost, with many endogenous species (including fauna) having been reported as endangered (Morellato and Haddad, 2000). The edible seeds of *A. angustifolia* provide a good food supply source for the fauna, especially birds such as the azure jay (*Cyanocorax caeruleus*), an

endemic species from southern Brazil that is classified as endangered. Other endangered fauna include the maned wolf (*Chrysocyon brachyurus*) and the vinaceous Amazon parrot (*Amazona vinacea*). Flora species have also been reported as endangered and include *Cabralea cangerana* (a neotropical tree), *Ocotea catarinenses* (a monoecious evergreen), and *Dicksonia sellowiana* (an arborescent fern).

Integrating different revenue sources such as timber and non-timber forest products (NTFP) as well as environmental services may be key to the future of species-rich forests, allowing standing forests to become economically competitive with other land uses (Klimas et al., 2012). Protecting and managing the current large areas of secondary and regrowth forests is one way of increasing forest coverage (Lamb et al., 2005). Many researchers defend the idea that native *Araucaria* forests should be sustainably managed for timber production, as this would financially benefit landowners with small farms whose main objective is usually to maximize their land revenue. This action would also promote expanding the area of native vegetation coverage because small landowners would place more importance on the native forests on their properties.

However, because the law restricts timber harvesting, even for scientific purposes, there are no studies available demonstrating the consequences of harvesting *A. angustifolia* and other tree species for timber production. Studies on managing these forests for timber production are needed to provide a better understanding of how native *Araucaria* forests would recover after being harvested for timber (Orellana et al., 2017).

The objective of this study was to evaluate the effects of harvesting timber on small farms with native *Araucaria* forest coverage in southern Brazil. Due to the restrictions imposed by law, we used an individual tree-growth model to simulate nine *A. angustifolia* harvesting scenarios. In addition, we simulated managing timber production for the forest as a whole by evaluating those scenarios that could sustainably supply *A.*

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